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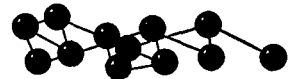
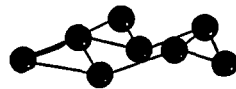
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Prospects in the Arts and Sciences

J. ROBERT OPPENHEIMER



THE words "prospects in the arts and sciences" mean two quite different things to me. One is prophecy: what will the scientist discover and the painters paint, what new forms will alter music, what parts of experience will newly yield to objective description? The other meaning is that of a view: what do we see when we look at the world today and compare it with the past?

I am not a prophet and I cannot very well speak to the first subject, though in many ways I should like to. I shall try to speak to the second, because there are some features of this view which seem to me so remarkable, so new and so arresting, that it may be worth turning our eyes to them; it may even help us to create and shape the future better, though we cannot foretell it.

In the arts and in the sciences it would be good to be a prophet. It would be a delight to know the future. I had thought for a while of my own field of physics and of those nearest to it in the natural sciences. It would not be too hard to outline the questions that natural scientists today are asking themselves and trying to answer. What, we ask in physics, is matter, what is it made of, how does it behave when it is more and more violently atomized, when we try to pound out of the stuff around us the ingredients which only violence creates and makes manifest? What, the chemists ask, are those special features of nucleic acids and proteins which make life possible and give it its characteristic endurance and mutability? What subtle chemistry, what arrangements, what reactions and controls make the cells of living organisms differentiate so that they may perform functions as oddly diverse as transmitting information throughout our

nervous systems or covering our heads with hair? What happens in the brain to make a record of the past, to hide it from consciousness, to make it accessible to recall? What are the physical features which make consciousness possible?

A Pattern for Predicting

All history teaches us that these questions that we think the pressing ones will be transmuted before they are answered, that they will be replaced by others, and that the very process of discovery will shatter the concepts that we today use to describe our puzzlement.

It is true that there are some who profess to see in matters of culture, in matters precisely of the arts and sciences, a certain macro-historical pattern, a grand system of laws which determines the course of civilization and gives a kind of inevitable quality to the unfolding of the future.

They would, for instance, see the radical, formal experimentation which characterized the music of the last half-century as an inevitable consequence of the immense flowering and enrichment of natural science; they would see a necessary order in the fact that innovation in music precedes that in painting and that in turn in poetry, and point to this sequence in older cultures.

They would attribute the formal experimentation of the arts to the dissolution, in an industrial and technical society, of authority—of secular, political authority, and of the Catholic authority of the Church. Thus they are armed to predict the future, but this, I fear, is not my dish.

If a prospect is not a prophecy, it is a view. What does the world of the arts and sciences look like? There are two ways of looking at it. One is the view of the traveler, going by horse or foot, from village to village to town, staying in each to talk with those who

live there and to gather something of the quality of its life. This is the intimate view—partial, somewhat accidental, limited by the limited life and strength and curiosity of the traveler, but intimate and human, in a human compass. The other is the vast view, showing the earth with its fields and towns and valleys as they appear to a camera carried in a high altitude rocket. In one sense this prospect will be more complete; one will see all branches of knowledge, one will see all the arts, one will see them as part of the vastness and complication of the whole of human life on earth. But one will miss a great deal; the beauty and warmth of human life will largely be gone from that prospect.

It is in this vast high altitude survey that one sees the general surprising quantitative features that distinguish our time. This is where the listings of science and endowments and laboratories and books published show up; this is where we learn that more people are engaged in scientific research today than ever before, that the Soviet World and the Free World are running neck and neck in the training of scientists, that more books are being published per capita in England than in the United States, that the social sciences are pursued actively in America, Scandinavia, and England, that there are more people who hear the great music of the past, and more music is composed and more paintings are painted.

From Vastness to Intimacy

This is where we learn that the arts and sciences are flourishing. This great map, showing the world from afar and almost as to a stranger, would show more: it would show the immense diversity of culture and life, diversity in place and tradition for the first time clearly manifest on a really world-wide scale, diversity in technique and language, separating sci-

This address was given at the close of the year-long Columbia University Bicentennial Celebration, December 26, 1954.

ence from science and art from art, and all of one from all of the other.

This great map—world-wide, culture-wide, remote—has some odd features. There are innumerable villages. Between the villages there appear to be almost no paths discernible from this high altitude. Here and there, passing near a village, sometimes through its heart, there will be a sort of superhighway, along which windy traffic moves at enormous speed.

The superhighways seem to have little connection with the villages—starting anywhere, ending anywhere and sometimes appearing almost by design to disrupt the quiet of the village. This view gives us no sense of order or of unity. To find these we must visit the villages—the quiet, busy places, the laboratories and studios, and studios. We must see the paths that are barely discernible; we must understand the superhighways and their dangers.

In the natural sciences these are, and have been, and are likely to continue to be, heroic days. Discovery follows discovery, each both raising and answering questions, each ending a long search, and each providing the new instruments for a new search.

There are radical ways of thinking unfamiliar to common sense and connected with it by decades or centuries of increasingly specialized and unfamiliar experience. There are lessons of how limited, for all its variety, the common experience of man has been with regard to natural phenomena, and hints and analogies as to how limited may be his experience with man.

Every new finding is a part of the instrument kit of the sciences for further investigation and for penetrating into new fields. Discoveries of new knowledge fructify technology and the practical arts, and these in turn pay back refined techniques, new possibilities of observation and experiment.

Communities of Scientists

In any science there is a harmony between practitioners. A man may work as an individual, learning of what his colleagues do through reading or conversation; or he may be working as a member of a group on problems whose technical equipment is too massive for individual effort. But whether he is part of a team or solitary in his own study, he, as a professional, is a member of a community.

His colleagues in his own branch of science will be grateful to him for

the inventive or creative thoughts he has, will welcome his criticism. His world and work will be objectively communicable and he will be quite sure that, if there is error in it, that error will not long be undetected. In his own line of work he lives in a community where common understanding combines with common purpose and interest to bind men together both in freedom and in cooperation.

This experience will make him acutely aware of how limited, how inadequate, how precious is this condition of his life; for in his relations with a wider society there will be neither the sense of community nor of objective understanding. He will sometimes find, it is true, in returning to practical undertakings, some sense of community with men who are not expert in his science, with other scientists whose work is remote from his, and with men of action and men of art.

The frontiers of science are separated now by long years of study, by specialized vocabularies, arts, techniques, and knowledge from the common heritage even of a most civilized society, and anyone working at the frontier of such science is in that sense a very long way from the practical arts that were its matrix and origin, as indeed they were of what we today call art.

Role in the Universities

The specialization of science is an inevitable accompaniment of progress; yet it is full of dangers, and it is cruelly wasteful, since so much that is beautiful and enlightening is cut off from most of the world. Thus it is proper to the role of the scientist that he not merely find new truth and communicate it to his fellows, but that he teach, that he try to bring the most honest and intelligible account of new knowledge to all who will try to learn.

This is one reason—it is the decisive organic reason—why scientists belong in universities. It is one reason why the patronage of science by and through universities is its most proper form; for it is here, in teaching, in the association of scholars, and in the friendships of teachers and taught, of men who by profession must themselves be both teachers and taught, that the narrowness of scientific life can best be moderated and that the analogies, insights, and harmonies of scientific discovery can find their way into the wider life of man.

In the situation of the artist today there are both analogies and differences from that of the scientist; but it is the differences which are the most striking and which raise the problems that touch most on the evil of our day.

For the artist it is not enough that he communicate with others who are expert in his own art. Their fellowship, their understanding, and their appreciation may encourage him; but that is not the end of his work, nor its nature. The artist depends on a common sensibility and culture, on a common meaning of symbols, on a community of experience and common ways of describing and interpreting it. He need not write for everyone or paint or play for everyone. But his audience must be man; it must be man, and not a specialized set of experts among his fellows.

Today that is very difficult. Often the artist has an aching sense of great loneliness, for the community to which he addresses himself is largely not there; the traditions and the culture, the symbols and the history, the myths and the common experience, which it is his function to illuminate and to harmonize and to portray, have been dissolved in a changing world.

There is, it is true, an artificial audience maintained to moderate between the artist and the world for

“When will it come about that the learned ones of the world will turn the wonderful discovery of the profound forces of matter exclusively to purposes of peace: to enable man’s activity to produce energy at a low cost which would alleviate the scarcity and correct the unequal geographical distribution of the sources of wealth and work, as also to offer new arms to medicine and agriculture, and to peoples’ new fountains of prosperity and well being.”

—POPE PIUS XII

from His Easter Message, 1954.

which he works: the audience of the professional critics, popularizers, and advertisers of art. But though, as does the popularizer and promoter of science, the critic fulfills a necessary present function, and introduces some order and some communication between the artist and the world, he cannot add to the intimacy and the directness and the depth with which the artist addresses his fellow men.

To the artist's loneliness there is a complementary great and terrible barrenness in the lives of men. They are deprived of the illumination, the light and tenderness and insight of an intelligible interpretation, in contemporary terms, of the sorrows and wonders and gaieties and follies of man's life.

This may be in part offset, and is, by the great growth of technical means for making the art of the past available. But these provide a record of past intimacies between art and life; even when they are applied to the writing and painting and composing of the day, they do not bridge the gulf between a society too vast and too disordered, and the artist trying to give meaning and beauty to its parts.

Qualitative Change in World

In an important sense, this world of ours is a new world, in which the unity of knowledge, the nature of human communities, the order of society, the order of ideas, the very notions of society and culture have changed and will not return to what they have been in the past. What is new is new not because it has never been there before, but because it has changed in quality.

One thing that is new is the prevalence of newness, the changing scale and scope of change itself, so that the world alters as we walk in it, so that the years of man's life measure not some small growth or rearrangement of moderation of what he learned in childhood, but a great upheaval.

What is new is that in one generation our knowledge of the natural world engulfs, upsets, and complements all knowledge of the natural world before. The techniques, among which and by which we live, multiply and ramify, so that the whole world is bound together by communication, blocked here and there by the immense synapses of political tyranny.

The global quality of the world is new: our knowledge of and sympathy with remote and diverse peoples, our

involvement with them in practical terms and our commitment to them in terms of brotherhood. What is new in the world is the massive character of the dissolution and corruption of authority, in belief, in ritual, and in temporal order.

Yet this is the world that we have come to live in. The very difficulties which it presents derive from growth in understanding, in skill, in power. To assail the changes that have unmoored us from the past is futile, and, in a deep sense, I think it is wicked. We need to recognize the change and learn what resources we have.

Again I will turn to the schools, and, as their end and as their center, the universities. For the problem of the scientist is in this respect not different from that of the artist, nor of the historian. He needs to be a part of the community, and the community can only, with loss and peril, be without him. Thus it is with a sense of interest and hope that we see a growing recognition that the creative artist is a proper charge on the university, and the university a proper home for him; that a composer or a poet or a playwright or painter needs the toleration, understanding, the rather local and parochial patronage that a university can give; and that this will protect him to some extent from the tyranny of man's communication and professional promotion.

For here there is an honest chance that what the artist has of insight and of beauty will take root in the community and that some intimacy and some human bonds can mark his relations with his patrons. For a university rightly and inherently is a place where the individual man can form new syntheses, where the accidents of friendship and association can open a man's eyes to a part of science or art which he had not known before, where parts of human life, remote and perhaps superficially incompatible one with the other, can find in men their harmony and their synthesis.

These then, in rough and rather general words, are some of the things we see as we walk through the villages of the arts and of the sciences and notice how thin are the paths that lead from one to another, and how little in terms of human understanding and pleasure the work of the villages comes to be shared outside.

Mass Voices Also Blighting

The superhighways do not help. They are the mass media—from the loud speakers in the deserts of Asia

Minor and the cities of Communist China to the organized professional theatre of Broadway. They are the purveyors of art and science and culture for the millions upon millions—the promoters who represent the arts and sciences to humanity and who represent humanity to the arts and sciences; they are the means by which we are reminded of the famine in remote places or of war or trouble or change; they are the means by which this great earth and its peoples have become one to another, the means by which the news of discovery or honor, and the stories and songs of today travel and resound throughout the world.

But they are also the means by which the true human community, the man knowing man, the neighbor understanding neighbor, the schoolboy learning a poem, the women dancing, the individual curiosity, the individual sense of beauty are being blown dry and issueless, the means by which the passivity of the disengaged spectator presents to the man of art and science the bleak face of unhumanity.

For the truth is that this is indeed inevitably and increasingly an open, and inevitably and increasingly, a closed world. We know too much for one man to know much, we live too variously to live as one. Our histories and traditions—the very means of interpreting life—are both bonds and barriers among us. Our knowledge separates as well as it unites; our orders disintegrate as well as bind; our art brings us together and sets us apart. The artist's loneliness, the scholar's despairing, because no one will any longer trouble to learn what he can teach, the narrowness of the scientist, these are not unnatural insignia in this great time of change.

Facing Wider Understanding

For what is asked of us is not easy. The openness of this world derives its character from the irreversibility of learning; what is once learned is part of human life. We cannot close our minds to discovery, we cannot stop our ears so that the voices of far off and strange people can no longer reach them. The great cultures of the East cannot be walled off from ours by impassable seas and defects of understanding based on ignorance and unfamiliarity. Neither our integrity as men of learning nor our humanity allows that. In this open world what is there any man may try to learn.

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This is no new problem. There has always been more to know than one man could know; there has always been a mode of feeling, many modes of feeling, that could not move the same heart; there have always been deeply held beliefs that could not be composed into a synthetic union.

Yet never before today has the diversity, the complexity, the richness so clearly defied hierarchical order and simplification, never before have we had to understand the complementary, mutually not compatible ways of life, and recognize choice between them as the only course of freedom.

Never before today has the integrity of the intimate, the detailed, the true art, the integrity of craftsmanship and the preservation of the familiar, of the humorous and the beautiful stood in more massive contrast to the vastness of life, the greatness of the globe, the otherness of people, the otherness of ways and the all-encompassing dark.

This is a world in which each of us, knowing his limitations, knowing the evils of superficiality and the terrors of fatigue, will have to cling to what is close to him, to what he knows, to what he can do, to his friends, and his tradition and his love, lest he be dissolved in a universal confusion and know nothing and love nothing. It is at the same time a world in which none of us can find hieratic prescription or general sanction for any ignorance, any insensitivity, any indifference.

When a friend tells of a new discovery, we may not understand, we may not be able to listen without jeopardizing the work that is ours and closer to us; but we cannot find in a book or canon—and we should not seek—grounds for hollowing our ignorance. If a man tells us that he sees differently than we or that he finds beautiful what we find ugly, we may have to leave the room, from fatigue or trouble; but that is our weakness and our default.

If we must live with a perpetual sense that the world and the men in it are greater than we and too much for us, let it be the measure of our virtue that the limits of our powers correspond to some special wisdom in our choice of life, of learning, or of beauty.

This balance—this perpetual, precarious, impossible balance between the infinitely open and the intimate,

this time—our twentieth century—has been long in coming; but it has come. It is, I think, for us and our children, the only way.

This is for all men. For the artist and for the scientist there is a special problem and a special hope, for in their extraordinarily different ways, in their lives that have increasingly divergent character, there is still a sensed bond, a sensed analogy.

Both the man of science and the man of art live always at the edge of mystery, surrounded by it; both always, as the measure of their creation, have had to do with the harmonization of what is new and what is familiar, with the balance between novelty and synthesis, with the struggle to make partial order in total chaos.

They can, in their work, and in their lives help themselves, help one

another, and help all men. They can make the paths that connect the villages of arts and sciences with each other, and with the world at large, the multiple, varied, precious bonds of a true and world-wide community.

This cannot be an easy life. We shall have a rugged time of it to keep our minds open and to keep them deep, to keep our sense of beauty and our ability to make it, and our occasional ability to see it, in places remote and strange and unfamiliar; we shall have a rugged time of it, all of us, in keeping these gardens in our villages, in keeping open the manifold, intricate, casual paths, to keep these flourishing in a great open windy world; but this is, as I see it, the condition of man; and in this condition we can help, because we can love one another.

Fall-out Hazard

An Erratum by

JAMES ARNOLD

THE editors of *Popular Science* magazine have sent the writer some calculations made for a proposed article on the fall-out hazard. The calculations are based in part on a figure given in an article¹ by the writer for the hazard due to carbon 14 from a fusion bomb. It now appears that this figure is, fortunately but embarrassingly, incorrect.

The erroneous statement, contained in the final paragraph of the article, is that if fifty tons of neutrons escape from a nuclear explosion, enough carbon 14 would be produced, if mixed with the atmosphere and living matter, to give a total internal body dosage of 15 mr/day to the average human. The correct figure is in the neighborhood of 5 mr/week or about twenty times less.

It seems worth while to call attention to this error a little more forcibly than with the usual "erratum." Although the calculation is not a difficult one, it has not been made elsewhere in the open literature to my knowledge.

The natural carbon 14 in our bodies contributes only 0.12 mr/week, perhaps 2 per cent of each person's total radiation dose from "natural"

¹ "The Hydrogen-Cobalt Bomb," *Bulletin*, 6 (June 1950), 290.

sources, i.e., cosmic rays, and the radioactivity of man himself and his normal environment. Rough calculations based on the estimated energy release of the fusion tests so far, indicate that these tests will change this small percentage itself by at most a few per cent. Thus there is no cause for concern over radiation hazards due to carbon 14 at the present time.

The main conclusions of the article on the cobalt bomb danger are, of course, not affected in any way by this error, which involves a hazard which was considered to be minor, even with the old figure. It may be worth while, however, to look again at this article, now four years old. There are two points in which our knowledge has advanced. First, the H-bomb is no longer "between possible and probable." It is no longer an idea, but a thing. Second, my estimates for the cost of materials for a cobalt bomb were undoubtedly too high. Deuterium is apparently cheaper than was indicated, by how much it is hard to say. Also, thanks in part to television, cobalt is now produced on a much larger scale than in 1950.

There is correspondingly less doubt that the cobalt bomb could be made. One thing seems clear from recent events—it had better not be tested.